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Electron Beam Treatment for Potable Water Reuse: Removal of Bromate and Perfluorooctanoic Acid

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Water availability is a major problem facing many regions around the world. To meet growing residential and agricultural needs, effective technologies have to be adopted to address microbial and chemical contaminants as part of water reuse programmes. The underlying hypothesis was that electron beam (EB) technology can breakdown the emerging contaminants of concern in water reclamation and reuse projects. We also hypothesized that the inactivation and elimination of contaminants by EB technology can be achieved cost-effectively. Having this technology in the "tool-box"of water reclamation technologies would open up innovative high-value, commercially-viable, and environmentally sustainable solutions and strategies for water reuse.

In this study, EB irradiation was investigated as a method for removing bromate and perfluorooctanoic acid (PFOA) from a synthetic water designed to simulate a treated wastewater intended for potable water reuse. In the absence of oxygen, an exponential model was able to relate bromate concentration to absorbed dose. However, a more complex model was needed to describe PFOA defluorination, so a model was developed that assumed formation of one partially defluorinated intermediate and this model was used to describe the relationship between free fluoride concentration and absorbed dose. Nitrate negatively affected the removal of bromate and the dose constant was inversely proportional to the nitrate concentration as predicted by a simple model that assumes the presence of radical scavengers. In contrast, the presence of nitrate improved the degradation of PFOA, possibly due to formation of oxidizing radicals or by other reactions of nitrate degradation products. Fulvic acid and alkalinity exerted negligible influences on bromate removal. Fulvic acid dampened the defluorination efficiency, probably due to the scavenging of oxidizing radicals such as the hydroxyl radical ($^{\bullet}$OH). Alkalinity was found to accelerate PFOA defluorination, possibly because of the formation and reactivity of the carbonate radical ($CO_3^{-\bullet}$). As pH increased from 5.0 to 7.3, the dose constant for bromate removal increased from 0.45/kGy to 0.69/kGy, but it barely changed when pH was further increased to 9.0. In the presence of oxygen, both contaminants were degraded less efficiently and showed more complex patterns of degradation. Pretreatment to remove dissolved oxygen would probably be needed to apply EB in practice for degradation of bromate and PFOA.

Country/Organization invited to participate

United States of America

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